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MANUFACTURE OF MALLEABLE IRON AND STEEL.

By HENRY BESSEMER.

[Abstract of Paper read at the Institution of Civil Engineers.]

Attention was directed, in the early part of the paper, to the ordinary mode of manufacturing iron by the puddling process, in the course of which the iron, after it "came to nature," was gathered into balls, and was then removed as quickly as possible to the squeezer, where much of the fluid scoria, with other mechanically mixed impurities, was driven out, leaving a mass or billet of iron composed of thousands of separate fragments of metal, the entire surface of every one of which was more or less coated with dry oxide, or fluid silicate of the oxide of iron. The great pressure exerted by the squeezer sufficed to so far remove the fluid coating of the contiguous particles as to bring their surfaces into actual contact, and consequently to effect an union at such parts. But the whole of the matter thus displaced could not find its way between the interstices of the mass, and, therefore, became locked in its numerous cavities, producing points of weakness and separation in the metal. No amount of after working, or rolling, could wholly displace the portions of cinder, dry oxide of iron, and of sand, which thus became mixed up with and were diffused throughout the mass, causing flaws and cracks in the iron, all more or less objectionable.

Now, if these imperfections were the natural and inevitable consequences of the conditions under which malleable iron was at present produced, it followed that defects of a similar character must also of necessity exist in steel produced by the puddling process. The granular condition of the metal, and its exposure to heat and oxygen, could not fail in both cases to oxidise the entire surfaces of the numerous molecules to be united into one mass; the admixture of scoria and other matters from the furnace was equally certain to result, and also the difficulty of bringing each particle of the metal to the same degree of decarbonisation and refinement existed as in the making of iron, with the additional inconvenience arising from some portions of the metal becoming entirely decarbonised, and being converted into soft malleable iron. Iron thus presented a most unfavourable contrast with the other malleable metals, all of which were free from sand or scoria; they had no hard or soft parts, and required no welding together of separate molecules, but they were perfectly homogeneous, and free from all mechanical admixture with foreign substances. Gold, silver, copper, zinc, tin, and lead owed this valuable exemption from the defects universally found in puddled iron simply to the fact that they were purified and refined in a fluid state, and while still fluid were formed into ingots, whereby the cohesion of every particle in the mass was insured. If, then, the refining of other malleable metals, while in a fluid state, and their formation into cast ingots, rendered all such metals more sound and homogeneous than iron, while it did not lessen their extreme ductility, why should iron for ever remain an exception to the general rule? It might be truly answered, that hitherto the excessively high temperature required to fuse and to maintain pure iron in a fluid state had interposed an insuperable barrier, for the highest heat of the furnaces only sufficed to show that fluidity was a possible condition of that metal.

It need not, therefore, be a matter of surprise, that when Mr. Bessemer first proposed to convert crude pig-iron into malleable iron while in a fluid state, and to retain the fluidity of the metal for a sufficient time to adit of its being cast into moulds, without the employment of any fuel in the process, his proposition was looked upon by many as a chimera, or as the mere day-dream of an enthusiast; but it was, nevertheless, fully recognised and supported by many of the scientific men of the day. The same deep conviction of the truth on which the new process was based, and which led Mr. Bessemer to bring it before the British Association, in 1856, has since determined him (in spite of the opinions then pronounced against the process) to pursue one undeviating course until the present time, and to remain silent for years, under the expressed doubts of those who predicted its failure, rather than again bring forward the invention until it had been practically and commercially worked, and there had been produced by it both iron and steel, of a quality which could not be surpassed by any iron or steel made by the tedious and expensive processes now in general use. The want of success which attended some of the early experiments was erroneously attributed by some persons to the "burning" of the metal, and by others to the absence of cinder, and to the crystalline condition of cast metal. It was almost needless to say that neither of the causes assigned had anything to do with the failure of the process in those cases where failure had occurred. Chemical investigation soon pointed out the real source of difficulty. It was found, that although the metal could be wholly decarbonised, and the silicum be removed, the quantity of sulphur and of phosphorus was but little affected; and as different samples were carefully analysed, it was ascertained that red shortness was always produced by sulphur when present to the extent of one-tenth per cent., and that cold shortness resulted from the presence of a like quantity of phosphorus; it, therefore, became necessary to remove those substances. Steam and pure hydrogen gas were tried, with more or less success, in the removal of sulphur, and various fluxes, composed chiefly of silicates of the oxide of iron and manganese, were brought in contact with the fluid metal, during the process, and the quantity of phosphorus was thereby reduced. Thus many months were consumed in laborious and expensive experiments; consecutive steps in advance were made, and many valuable facts were elicited. The successful working of some of the higher qualities of pig-iron caused a total change in the process to which the efforts of Messrs. Bessemer and Longsdon were directed. It was determined to import some of the best Swedish pig-iron, from which steel of excellent quality was made, and tried for almost all the uses for which steel of the highest class was employed. It was then decided to discontinue for a time all further experiments, and to erect steel works at Sheffield, for the express purpose of fully developing and working the new process commercially, and thus to remove the erroneous impressions so generally entertained in reference to the Bessemer process.

In manufacturing tool steel of the highest quality, it was found preferable, for several reasons, to use the best Swedish pig-iron, and, when converted into steel by the Bessemer process, to pour the fluid steel into water, and afterwards to remelt the shotted metal in a crucible, as at present practised in making blister-steel, whereby the small ingots required for this particular article were more perfectly and more readily made.

It was satisfactory to know that there existed in this country vast, and apparently inexhaustible, beds of the purest ores fitted for the process. Of the hematite alone 970,000 tons were raised annually, and this quantity might be doubled, or trebled, whenever a demand arose. It was from the hematite pig-iron, made at the Workington Iron-Works, that most of the larger samples of iron and steel exhibited were made. About 1 ton 3 cwts. of ore, costing 10s. per ton, would yield 1 ton of pig metal, with 60 per cent. less lime, and 20 per cent. less fuel, than were generally consumed when working inferior ores; while the furnaces using this ore alone yielded from 220 to 240 tons per week, instead of, say, 160 to 180 tons per week, when working with common ironstone. The Cleator Moor, the Weardale, and the Forest of Dean Iron-Works also produced an excellent metal for this purpose.

The form of the converting vessel which had been found most suitable somewhat resembled the glass retort used by chemists for distillation. It was mounted on axes, and was lined with "Ganister," or road drift, which lasted during the conversion of thirty or forty charges of steel, and was then quickly and cheaply repaired, or renewed. The vessel was brought into an inclined position to receive the charge of crude iron, during which time the tuyeres were above the surface of the metal. As soon as the whole charge was run in the vessel was moved on its axes, so as to bring the tuyeres below the level of the metal, when the process was at once brought into full activity, and twenty small, though powerful, jets of air sprung upwards through the fluid mass; the air expanding in volume divided itself into globules, or burst violently upwards, carrying with it a large quantity of the fluid metal, which again fell back into the boiling mass below. The oxygen of the air appeared in this process first to produce the combustion of the carbon contained in the iron, and at the same time to oxidise the silicum, producing silicic acid, which uniting with the oxide of iron obtained by the combustion of a small quantity of metallic iron, thus produced a fluid silicate of the oxide of iron, or "cinder," which was retained in the vessel, and assisted in purifying the metal. The increase of temperature which the metal underwent, and which seemed so disproportionate to the quantity of carban and iron consumed, was doubtless owing to the favourable circumstances under which combustion took place. There was no intercepting material to absorb the heat generated, and to prevent its being taken up by the metal, for heat was evolved at thousands of points, distributed throughout the fluid, and when the metal boiled the whole mass rose far above its natural level, forming a sort of spongy froth, with an intensely vivid combustion going on in every one of its numberless, ever-changing cavities. Thus by the mere action of the blast a temperature was attained, in the largest masses of metal, in ten or twelve minutes that whole days of exposure in the most powerful furnace would fail to produce.

The amount of decarbonisation of the metal was regulated, with great accuracy, by a meter, which indicated on a dial the number of cubic feet of air that had passed through the metal; so that steel of any quality or temper could be obtained with the greatest certainty. As soon as the metal had reached the desired point (as indicated by the dial) the workmen moved the vessel so as to pour out the malleable iron or steel into a founder's ladle, which was attached to the arm of a hydraulic crane, so as to be brought readily over the moulds. The ladle was provided with a fire-clay plug at the bottom, the raising of which, by a suitable lever, allowed the fluid metal to descend in a clear vertical stream into the moulds. When the first mould was filled the plug valve was depressed, and the metal was prevented from flowing until the casting ladle was moved over the next mould, when the raising of the plug allowed this to be filled in a similar manner, and so on until all the moulds were filled.

The casting of large masses of a perfectly homogeneous malleable metal into any desired form, rendered unnecessary the tedious, expensive, and uncertain operation of welding now employed wherever large masses were required. The extreme toughness and extensibility of the Bessemer iron was proved by the bending of cold bars of iron 3 in. square, under the hammer, into a close fold, without the smallest perceptible rupture of the metal at any part; the bar being extended on the outside of the bend from 12 in. to 16¾ in., and being compressed on the inside from 12 in. to 7¼ in., making a difference in length of 9½ inches, between what, before bending, were the two parallel sides of a bar 3 in. square. An iron cable, consisting of four strands of round iron 1½ in. diameter, was so closely twisted, while cold, as to cause the strands at the point of contact, to be permanently imbedded into each other. Each of these strands had elongated 12½ in. in a length of 4 ft., and had diminished 1-10th of an inch in diameter throughout their whole length. There were also exhibited some steel bars 2 in. square and 2 ft. 6 in. in length, twisted cold into a spiral, the angles of which were about 45°, and some round steel bars, 2 inches in diameter, bent cold under the hammer into the form of an ordinary horse shoe magnet, the outside of the bend measuring 5 in. more than the inside.

The steel and iron boiler plates, left without shearing, and their ends bent over cold, also afforded ample evidence of the extreme tenacity and toughness of the metal; while the clear even surface of the railway axle and piece of malleable iron ordnance, were examples of the perfect freedom from cracks, flaws, or hard veins, which formed so distinguishing a characteristic of the new metal. The tensile strength of this metal was not less remarkable, as the several samples of steel tested in the proving machine at Woolwich Arsenal, bore, according to the reports of Colonel Eardley-Wilmot, R.A., a strain varying from 150,000 lbs., to 162,900 lbs. on the square inch, and four samples of iron boiler plate from 68,314 lbs. to 73,100 lbs.; while according to the published experiments of Mr. W. Fairbairn, Staffordshire plates bore a mean strain of 45,000 lbs., and Low Moor and Bowling plates a mean of 57,120 lbs. per square inch.

There was also another fact of great importance, in a commercial point of view. In the manufacture of plates for boilers and for ship-building the cost of production increased considerably with the increase of weight in the plate: for instance, the Low Moor Iron Company demanded 22*l.* per ton for plates weighing 2½ cwts. each; but if the weight exceeded 5 cwts. then the price rose from 22*l.* to 37*l.* per ton. Now, with cast ingots, such as the one exhibited, and from which the sample plates were made, it was less troublesome, less expensive, and less wasteful of material, to make plates weighing from 10 to 20 cwts. than to produce smaller ones; and, indeed, there could be but little doubt that large plates would eventually be made in preference, and that those who wanted small plates would have to cut them from the large ones. A moment's reflection would, therefore, show the great economy of the new process in this respect; and when it was remembered that every rivetted joint in a plate reduced the ultimate strength of each 100 lbs. to 70 lbs., the great value of long plates for girders and for ship-building would be fully appreciated.

At a time when the manufacture of ordnance occupied so large a share of public attention, it was interesting briefly to point out the great facility which the Bessemer process afforded of forming masses, both of malleable iron and of steel, of a size suitable for the heaviest ordnance, without any welding together of separate slabs, or the more costly mode of building up the gun with pieces accurately turned and fitted together. Many attempts had been made to produce wrought-iron ordnance, and this object had been successfully accomplished in the case of the large gun produced at the Mersey forge. But, however perfect this one gun might be, the time required to make it, and its immense cost, manifestly rendered it still a great desideratum to produce guns rapidly and cheaply, of a material equal to, or greater in tensile strength than wrought-iron, and, if possible, free from the liability which that material had to flaws and to deterioration, during its long exposure to a welding heat. It was believed that the Bessemer process supplied this desideratum, as masses of cast malleable metal could be produced of 10 or 20 tons in weight in a single piece, and two or three such pieces might be conveniently made by the same apparatus in one day. The metal so made might be either soft malleable iron, or soft steel. In order to prove the extreme toughness of such iron, and the strain to which it might be subjected without bursting, several cast and hammered cylinders were placed cold under the steam-hammer, and were crushed down without the least tearing of the metal, as was shown by the samples exhibited. These cylinders were drawn from a round cast-iron ingot of only 2 in. greater diameter than the finished cylinder, and in the precise way in which a gun would be treated; they might, therefore, be considered as short sections of an ordinary 9-pounder field-piece. The tensile strength of the samples, as tested at the Royal Arsenal, was 64,566 lbs. per square inch; while the tensile strength of pieces cut from the Mersey gun gave a mean of 50,624 lbs. longitudinally, and 43,339 lbs. across the grain; thus showing a mean of 17,550 lbs. per square inch in favour of the Bessemer iron.

If it was desired to produce ordnance by merely casting the metal, the ordinary founding process might be employed, with the simple difference that the iron, instead of running direct from the melting furnace into the mould must first be run into the converting vessel, where in 10 minutes it would become steel, or malleable iron, as was desired, and the casting might then take place in the ordinary manner. The small piece of ordnance exhibited served to illustrate this important manufacture, and it was interesting, in consequence of its being the first gun that was ever made of malleable iron, without a weld or joint. The importance of this fact would be enhanced when it was known that conical masses of this pure tough metal, of from 5 to 10 tons in weight, could be produced at Woolwich at a cost not exceeding 6*l.* 12*s.* per ton, inclusive of the cost of pig-iron, carriage, remelting, waste in the process, labour, and engine-power. The conical ingots being cast in iron moulds, the great delay in moulding in loam would be avoided, and as the iron moulds employed might be removed from the casting-pit within an hour after the metal had been poured into them, the tedious interval of three days, now required by the cast-iron guns before removal, would be also avoided, thus immensely increasing the capabilities of the foundry. If it were assumed that these advantages were about equal to the cost of hammering the cast ingot, then, by this process, it would be practicable to produce guns of any size in hammered cast-steel or malleable iron ready for the boring mill at about the same cost as the cast-iron guns now in use; but if the weight of the guns could be reduced by 20 or 25 per cent., in consequence of their superior strength, then an actual saving in that proportion would be effected in the first cost of every gun so made. These important facts had been laid before the Government, and their advantages were stated to be fully appreciated by Colonel Eardley-Wilmot, the Superintendent of the Royal Gun Factories, who had evinced a great interest in the progress of the invention from its earliest date, and to whose kindness the author was indebted for the many valuable trials of the tensile strength of the various samples of metal that had been submitted for investigation.

It would be interesting to those who were watching the advancement of the new process to know that it was already rapidly extending itself over Europe. The firm of Daniel Elfstrand and Co., of Edsken, who were the pioneers in Sweden, had now made several hundred tons of excellent steel by the Bessemer process. Another large manufactory had since been started in their immediate neighbourhood, and three other companies were also making arrangements to use the process. The authorities in Sweden had fully investigated the whole process, and had pronounced in favour of it. The large steel circular saw plate exhibited was made by Mr. Göranson, of Geffle, in Sweden, the ingot being cast direct from the fluid metal within 15 minutes of its leaving the blast-furnace. In France the process had been for some time carried on by the old-established firm of James Jackson and Son, at their steel-works, near Bordeaux. This firm was about to manufacture puddled steel on a large scale. They had already got a puddling furnace erected, and in active operation, when their attention was directed to the Bessemer process, the apparatus for which was put up at their works last year; and they were now extending their field of operations, by putting up more powerful apparatus at the blast-furnaces in the Landes. There were also four other blast-furnaces in the South of France in course of erection, for the purposes of carrying out the new process.

The irons of Algeria and Saxony had produced steel of the highest quality.

Belgium was not much behind her neighbours; the process was now being carried into operation at Liège, where excellent steel had been made from the native coke iron; while in Sardinia preparations were also being made for working the system. Russia had sent to London an engineer and a professor of chemistry to report on the process, and Prof. Müller, of Vienna, and M. Dumas and others from Paris, had visited Sweden, to inspect and report on the working of the new system in that country.

The Bessemer process might, therefore, be now fairly considered an accomplished commercial fact, and in a country like England, where the manufacture of iron and steel formed so important a branch of the national industry, and was so necessary an element in all the great manufacturing operations, it must be admitted that an impartial examination of the new system was of the highest importance—not only to those immediately concerned in the production of malleable iron and steel, but to the country generally. That the process admitted of further improvement, and of a vast extension beyond its present limits, the author had no doubt; but those steps in advance would, he imagined, result chiefly from the experience gained in the daily commercial working of the process, and would most probably be the contributions of the many practical men who might be engaged in carrying on the manufacture of iron and steel by this system. Hitherto the process had been brought into its present practical and commercial state without recourse to any of the numerous inventions which were supposed by the several authors to be essential to the success of the system; but any real improvement that might be brought forward would be cordially received and encouraged.

THE IRON TRADE OF THE UNITED STATES.—The Iron Trade Association of the United States has at great expense succeeded in obtaining accurate statistics showing the actual position of the trade. The necessity for reliable information on this subject has been very frequently pointed out, and several attempts have been made to procure it, but the immense labour and expense incurred had prevented the completion of the task. Through the indefatigable industry of Mr. Lesley, the secretary of the association, assisted by Mr. Jos. Lesley and Mr. B. A. Lyman, during a period of nearly two years, and at an expense of $6000, defrayed entirely by voluntary contributions from the members of the Iron Trade Association, the first and only complete statement of the iron industry of the Union is

enabled to be published. The great facts demonstrated are that there are nearly 1200 efficient works in the Union; that these produce annually about 850,000 tons of iron, the value of which in an ordinary year is $50,000,000. Of this amount the portion expended for labour alone is about $35,000,000. The amount of rolled iron made in the whole United States is about 500,000 tons per annum. Of this about 300,000 tons is made east, and 200,000 tons west of the Alleghany mountains. The annual average importation of rolled iron for the eight years from 1850 to to 1857 inclusive, was about 305,000 tons, of which the Atlantic States consumed about 200,000 tons, making the total consumption of rolled iron in the seaboard States about 500,000 tons per annum, three-fifths of which is domestic and two-fifths foreign. The 105,000 tons of foreign iron consumed in the west and south-west is nearly all composed of rails. The smaller descriptions of iron consumed there are chiefly of domestic manufacture. At least seven-eighths of all the descriptions of imported iron, except rails, are consumed in the Atlantic States. The annual importation of railroad iron for the eight years, 1850 to 1857, averaged 202,000 tons, of which about one-half has been taken by the Atlantic States.

IMPROVEMENTS IN THE STEAM-ENGINE.

SIR,—From the course pursued against me, I am induced to present the following brief summary of the result of my 20 years' labour, and hope you will oblige me by its insertion.

Prior to my labours in connection with the improvement of the steam-engine, which commenced in 1838, it was held as established points that the steam could not be condensed by the atmosphere, so as to render it a substitute for water where it—that is, water—could not be obtained for the purpose; that practically the expansive use of steam was not successful but in the Cornish engine, and even in that engine practice showed that beyond 50 lbs. pressure no economy was effected, that the notions entertained by me upon the expansive use of high-pressure steam were all moonshine; that such high-pressure as I proposed was not practical in the condensing engine, and dangerous in all; that strictly tubular boilers and surface condensers in water had again and again been proved to be utterly worthless and were abandoned, and that the two-cylinder, or Woolf engine, was a useless piece of complication, which at that time was all but out of use in England. These were the views held, not only by the commonality, but by the first scientific and practical authorities at that time, and propounded by the scientific periodicals.

In 1842, 1843, and 1844, I practically proved that with air as the condensing medium an economy equal to the Cornish engine, with its unlimited supply of cold water, could be effected; and that in place of requiring, as in the Bolton and Watt engine, 1380 gallons of cold water per horse-power per day, 1 gallon per horse-power per day was all that was required. Further, that by means of strictly tubular boilers, properly made, and supplied with all suitable means to produce a thoroughly practical and economical result, I placed it beyond doubt that the great bugbear pressure, which at that time was said to be an insurmountable obstacle, was but a mere delusion, that had no real existence when boilers were made as sound science and correct practice dictate. I also demonstrated thus early that for all purposes, whether manufacturing, marine, or locomotive, the economy of the Cornish engine and boiler was obtainable, deposit prevented, sacrifice of life from explosions avoided, and a host of other practical and important objects gained; whilst, at the same time, the size and weight of engines and boilers were reduced tenfold as compared with the Cornish, and rendered much more portable and of less weight than the locomotive, and consequently safer, and better adapted for all purposes.

In 1845, a discovery was made and published by me relating to internal cooling in the expanding cylinder when steam is used expansively, in relation to which the most unblushing falsehood is being propagated, by which Watt is made the recipient of the stolen property, contrary to the plainest import of Watt's own authenticated explanations and practice, and that universally accepted up to 1846; but the parties are not very particular, as they sometimes pass it to the credit of others, but take care always not to credit the rightful owner with it. Prior to my explanation of this matter, practice and abstract principle did not agree; the consequence was that the expansive use of steam was maintained to be of little practical value out of Cornwall, or apart from the single-acting pumping-engine. But my explanation cleared away the fog, and now superheating of steam is not as previously employed upon the Ericsson, Stirling, and Haycraft system of enlarging the volume, but for the purpose of holding the water all in the shape of steam, from the time it enters the cylinder until it enters the condenser, whatever be the pressure and degree of expansion used. The consequence is that practical men are now rapidly discovering that sound abstract principle and correct practice accord. To minds to whom the importance of thus having cleared away the fog upon such a question as this are admissible, and who desire only to see merit given to whom it is due, the conduct pursued by the parties in question must appear reprehensible. Dr. Haycraft, in a letter given in the *Mechanics' Magazine*, dated March 12, 1850, after alluding to the universal ignorance which had existed upon this internal cooling, goes on to say—"While conversing with my brother on this subject, he remarked that he thought the cylinder cooled by the evaporation which took place within it during the time of the vacuum, as the interior must be covered by a film of water every time the steam is admitted. The cause of the evil (says the doctor) now appeared quite clear." But it should be known that after I had made these views public the doctor's brother, a stranger to me, called on me at my private apartments in Birmingham, and the explanation I gave him was that the loss did take place on the side of the piston that is open to the condenser, but on the other side also, as explained in my lectures, pp. 47 to 50 and 89 to 92.

In a long discussion in the *Engineer* a nameless correspondent, "J. B.," makes a charge against me of robbing Watt: a reply of mine will be found at page 334, volume 5. Another letter of mine, sent in time for the next week's publication, in which Watt's own account of his discoveries and views upon this head were given, was suppressed; and, strange to say, in a leader given in the same paper, and same volume, at page 445, this veritable "J. B." (which so far as anything of his personality is known to me should be written "J. B." and Co.), is credited with the chief merit in the affair. In the last leader upon this discussion, found at page 463, are these significant hints—"Engineers must attend to what lies next them to be done: they have to probe the action of the steam within the cylinder to satisfy themselves of the injurious precipitation and re-evaporation of the steam neutralising the efficiency of exhaustion; to apply and mature the means of preventing such condensation of the steam by the application of additional heat to the steam externally through the cylinder, or internally by superheating it; and to ensure an economically good vacuum in the condenser." Now, these are the views that for upwards of 13 years I have been urging in the public journals and my published lectures, having also provided means and practically demonstrated for years that such views are sound, and of great value in practice.

From 1842 to 1846 I practically supplied the outline of my numerous improvements in the expansive and condensing steam-engine. I was the first to practically demonstrate that steam at 100 lbs., 200 lbs., or any other pressure which did not entail too high temperatures, could be used in the condensing engine with quite as much facility, and far more economy, than when generated at 10 lbs. only; also to show that with double cylinders on the Woolf principle the cranks could be placed at right angles, which was done in the year 1843, and to apply this kind of engine in a direct-acting and locomotive-like manner, whether vertical, inverted, horizontal, or any other way, thus rendering it suited to marine or any purpose; this class of engine I have perfected in its general structure, its valves, its connecting-rod, and in the use of the crank at right angles. In a word, I have produced a mass of sound, and before they were accomplished were considered by the engineering world, difficult and impossible inventions, the practical results obtained from which were when I set out held to be utter impossibilities by all except myself. Let my opponents point out, if they can, the labours of any one man originating and maturing so much difficult and costly invention, and so instructing his fellow-creatures in a knowledge of it, at so little cost, as I have done in the face of the most powerful opposition the world can present. It is not my wish to depreciate Watt's invention, or that of any other person, but candid and well-informed men hereafter will see that his was not so comprehensive and difficult as mine, or greater in practical value, as is evident from the comparative results given below:—

Comparative Table.	Common practice.	My practice.
Cubic feet of space occupied by boilers of 500-horse power	6624	1666
Cubic feet of space occupied by steam cylinders for 500-horse power	822	312
Cooling surface of steam cylinders of the 500-horse power	561	272
Relative heat absorbing surface of boilers to coal burnt, in square feet	10	45
Relative grate surface to coal burnt, in square feet	2	5
Relative full theoretic effect of 1 lb. of coal, making 8 lbs. of steam at 25 lbs., and having no expansion, and 1 lb. of coal, making 12 lbs. of steam at 200 lbs., and with expansion to 6¼ lbs. pressure	1	7⅛
The same relative comparison, but with the 25 lbs. steam expanded to 12½ lbs.	1	4⅛
Weight of engine, 500-horse power ..... Tons	105	76
Weight of boiler, ditto ..... "	78	36
Water in the boiler, ditto ..... "	48	6
Coals for 14 days' steaming, ditto ..... "	387	129

On an inspection of the foregoing comparison, it will be seen that in a 500-horse power engine, with its supply of coal for a 14 days' voyage, the unprofitable load is reduced by 371 tons, and the paying capacity of the ship is thereby increased by that amount. What the rate per ton for goods by first-class steamers between London and New York is now I am not aware, but during the time of the Russian war it was 6*l*. To illustrate the case, I will suppose it to be 5*l*.; at such rate the increased value of the paying tonnage amounts to the sum of 1855*l*. per voyage; to this must be added the value of the coal saved, which, at only 1*l*. per ton, is equal to 258*l*. per voyage, or the total gain upon each voyage is 2113*l*. If, therefore, the vessel steamed but 258 days in the year, the gain per annum is 33,808*l*. The cost of my engines and boilers will be much less than that of the present, but if we put the cost of both kinds at 20,000*l*. for the 500-horse marine engine, it is seen that the gain per annum is nearly double the cost of the engine. Thus stands the comparison as stated in the table. But the coal, which will ultimately produce the same power for the fourteen days by my boilers and engines, will be nearly, if not quite, as 65 tons in place of 129 tons. But to carry the mode of illustration, as given in the tables 2 and 3, to the whole marine steam-power of Great Britain, including mercantile and naval, we may in round numbers put such power at 200,000 horse, which gives 13,523,200*l*. sterling as the gain per annum. My opponents may take any exception they please to the above figures, but as sure as they and I exist, the day is not far distant when the general practice of all maritime nations will confirm the general accuracy of my statements, and it is of the first importance to the position of the English nation, and the security and welfare of the English people, to see that they are not last in availing themselves of such improvements. It may be a light thing to such a nation to witness the injustice done to individuals, but when individuals become the representatives of mighty principles, which by them have been reduced to practice, it is not safe for England to neglect the principles nor their practical application. If the English public clearly saw the value of such things, it would rejoice that such means for extending human existence were brought within its reach. These means are of the utmost consequence for defence and attack in case of war, and of inestimable value in time of peace.

I have felt this statement necessary that the true position and prospects of my invention should be properly understood by the engineering profession and the general public.—*June* 9. T. CRADDOCK.

DISCOVERING WATER BY THE DIVINING ROD.—Some years since this subject engaged more of public attention than now, and some years back it fell in my way to be present at several experiments for discovering water by means of the divining rod. The instruments used for the purpose are either a forked hazel-twig or a steel spring; a common watch spring has been adopted in the cases under my observation. The *modus operandi* is as follows, but it should be premised that the individual operating is chosen for reputation of success, for, after all, as will appear presently, the very essence of the work is in some hidden property of the operator himself, which he cannot explain or communicate to others:—All being ready, the operator surveys the ground, and produces his mystic wand, which is a slip of hazel, cut close to a fork of two branches, each branch about 12 in. long; an end is grasped firmly in each hand, the hands being held with the knuckles under, the forked point of the twig projecting horizontally forward. The operator walks slowly onwards, varying his course to the right or left, under the influence, as it appears, of some hidden impulse. The company follow, the eyes of all attentively watching the twig, which appears to be held firm and immoveable. Suddenly the point of the fork deflects, becomes violently agitated, and dips to the earth, in spite of the apparent endeavours of the operator to resist the movement. He then stops, calls attention to the irresistible action of the twig, and says, "Here is water." The spot is forthwith marked, and the investigation goes on, with similar occurrences, in other places, all of which are duly marked as the course of a spring of water underneath; and it is for the party beneficially interested to choose the situation most convenient for his purposes to commence works for bringing this hidden spring of water to light. * * * The experiment took place on the estate of a gentleman, where other business had called me. During luncheon the subject of discovering water by means of the divining rod was started, and the wonderful effects and vast benefits which had accrued to the country around dwelt on. Seeing my incredulity on the subject, an immediate expedition for the removal of my doubts was determined upon, and the individual possessing the property was sent for, and forthwith he attended, and I was introduced to a very respectable farmer, whose appearance alone was sufficient to dispel any idea of deception; and having declared himself ready for the experiment, all present issued forth. The farmer produced a steel watch spring in coil, which extending, he held an end in each hand, in a similar manner as already explained with the hazel-twig, drawing his hands together so as to force the middle part of the spring forward, and form a bow. As the operator moved onwards the same effects took place, the projecting or bowed part of the spring becoming violently agitated, as with the hazel-twig. I held the spring myself in the same way the operator did; others present did the same; but it was perfectly still and impassive in all our hands. There were several individuals present not more likely than myself to be influenced by any superstitious feeling. It was suggested by one gentleman present as not improbable that some electrical or other subtle property existed in the individual.—Correspondent of the *Field*.

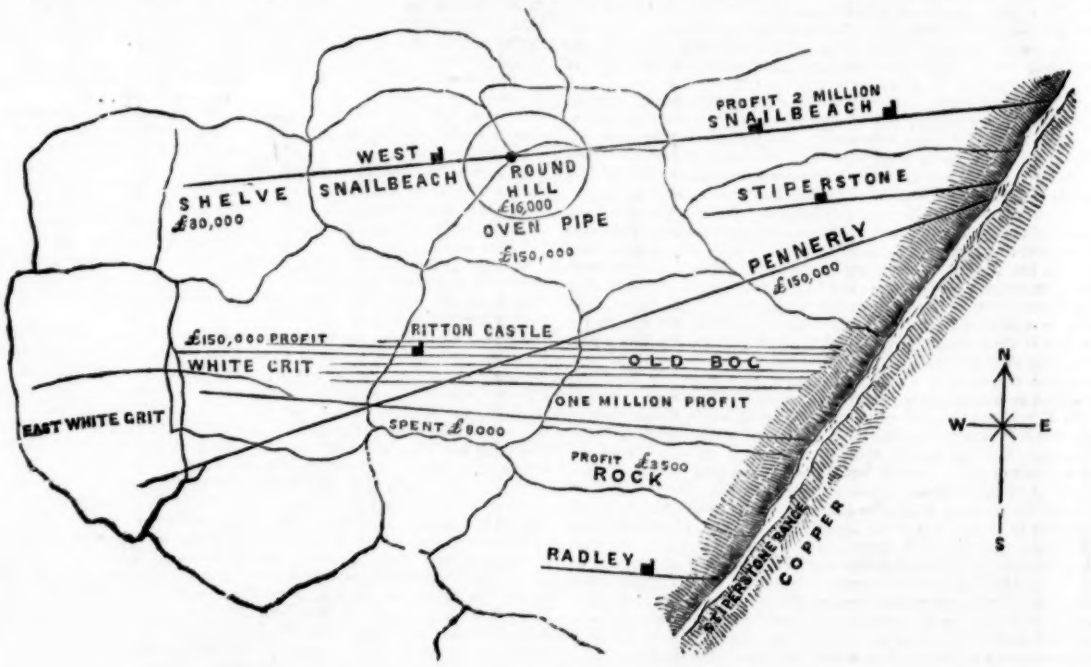
BLASTING POWDER.—Mr. Simon Davey, Rouen, has patented the employment of flour, bran, or other glutinous or starchy matter, to replace a part of the charcoal now employed in the manufacture of gunpowder. He has also invented a new mode of graining the same. The object of the invention is that the ingredients may be combined and grained without danger of explosion.

STEAM JACKETS.—The immense benefits derivable from the use of steam jackets is now beginning to be made known in the United States, Mr. Gordon Mackay having communicated to the Franklin Institute the results of experiments with and without the steam jacket, which prove that its use gives an economy of 20·5 per cent. The steam jacket is well known to Cornishmen, and Cornish mine adventurers may well congratulate themselves upon so excellent a contrivance being in use. It consists in casting the cylinder of the engine with an outer casing, and leaving a space between for the admission of steam from the boiler, so as to keep the steam in the cylinder at the same temperature throughout the whole length of the stroke of the piston. Although the experience of Watt was decidedly in favour of the steam jacket, many eminent authorities have argued against it, on the ground that "the steam jacket itself is subject to radiation as well as the cylinder, and as it has a far more extended surface more steam must be condensed in it than in the cylinder alone; therefore its use is a disadvantage, not a benefit." Against all adverse opinions, however, we have the indisputable facts that in Cornwall steam is generated with the expenditure of less fuel than in any other locality, coupled with the very conclusive results of Mr. Gordon Mackay's experiments.

SALFORD HOROLOGICAL SKILL.—Messrs. Bailey and Co., turret clock manufacturers, of the Albion Works, Salford, have just completed a very large turret clock for the new church at Haley Hill, Halifax, endowed by Mr. E. Ackroyd. The clock will show the time upon two dials, each 8 ft. 6 in. in diameter; it will have a small set dial to set the hands by, and it strikes the hours and quarters. The frame occupies a space of about 6 ft. by 3 ft. The most important part of the clock, the pendulum, is compensated, to counteract the injurious effect of the variations of temperature upon it. To parties interested a section of a pendulum on this principle may be inspected at the Peel Park Museum, presented by Mr. R. Roberts, C.E., it being his invention. The pendulum is regulated from the top instead of (as usually the case) from the bottom, and the rod, by a small dial, which can be made to rotate without stopping the clock. The pendulum is a "two seconds," that is to say, it performs 30 oscillations per minute. Its length is 156·55 in., rather more than 13 ft. ½ in. The bob weighs about 2 cwts. The main or great wheels are each 18 in. diameter. The patent wire ropes are used, and the clock is furnished with the maintaining power to keep it going whilst in process of winding. The arbour carriers are so arranged that any single wheel may be taken out without removing or altering the position of any part of the frame work. The price of this clock will be about 180*l*., fixed complete, and is about half the size of the Westminster clock.—*Salford Weekly News*.

REGISTERING PYROMETER.—Within the past few days an interesting addition has been made to the Polytechnic Exhibition by Mr. W. Gauntlett, of the South Bank Iron-works. A series of daily diagrams exhibits the temperature of the air of the hot blast as it enters the iron smelting furnaces. This instrument, simple in construction, metes off the temperature on a cylindrical roll of paper, which serves as a record for twenty-four hours. Mr. Gauntlett, the inventor, has recently secured a patent for this ingenious apparatus, which may be thus described. The cylindrical roll we have above referred to is ruled in lines, which describe the circumference of the roll, corresponding to the degrees of Fahrenheit's thermometer, extending to 1000 degrees of heat. At right angles with these are a series of vertical red lines which represent the consecutive hours of the day and night. Upon these papers, which are affixed in connection with a timepiece, and also in communication with the heated atmosphere, the temperature of which it is desired to register, the time and heat are continuously recorded by means of a small common lead pencil. The diagram exhibited consists of seven slips for each of the three furnaces, and exhibit the temperature of the heated air therein employed during every hour of the week; and it is somewhat interesting to observe the sinuous course which the line pursues, rising and falling (corresponding, no doubt, with the manner in which the fireman has attended to his duty). Along the line, at pretty nearly equal distances, we observe a series of very sudden depressions. The line appeared to fall down precipitately, and, after making a slight progression, to mount up and advance as before. These eccentric divergences mark, we are informed, the period when the furnaces were tapped, during which the heated air is shut off, and ceases to affect the instrument. The invention, we understand, has been highly appreciated by several ironmasters of this district; and we have some pleasure in noticing it, as one of the native productions emanating from the new and rising iron district of Cleveland.—*Stockton and Hartlepool Mercury*.

THE BOG LEAD MINING COMPANY [LIMITED].



Divided into 8000 shares of £5 each. Deposit, 5*s*. per share.
Incorporated by Act of Parliament 19 and 20 Vic., cap. 47, sec. 4 and 5, Jan., 1856.
The profits arising from former workings exceed £1,000,000 sterling.

DIRECTORS.

A. P. CLAYTON, Esq., Combe Bank.
RICHARD WOOD, Esq., Pen-y-Nant, Ruabon.
D. T. JOHNSON, Esq., 15, Cannon-street West.
WILLIAM HIND, Esq., St. John's Wood.
With power to add to their number.

BANKERS—Bank of London.
SOLICITOR—E. A. Marsden, Esq., 4, Size-lane.
CONSULTING MINING ENGINEER—Mr. Josiah Hugo Hitchins, of Devon Great Consols.
ENGINEER—Mr. William Mathews, of Devon Great Consols.
RESIDENT AGENTS—Capts. M. Redge and W. Kneebone.
SECRETARY—Mr. Thomas Fuller.

OFFICES—51, THREADNEEDLE STREET, LONDON.

PROSPECTUS.

This extensive and valuable mineral property has been granted by Henry Lyster, Esq., of Rowton Castle, Salop, and extends for nearly two square miles, and has yielded above one million sterling profit to the former proprietors, principally from a course of ore below the adit level, to the 163. Rich deposits of lead ore have recently been discovered above the adit level, and new lodes opened not before discovered, which will be intersected by short cross-cuts from the levels below.

The mines are surrounded by the celebrated Snailbeach, the richest lead mine in the world; Pennerly, Gravels, White Grit, Ritton Castle, and others. These mines produce one-tenth of all the lead in England.

Considering the many advantages of this mine, the vast improvements in machinery, and the great demand for lead, it is strongly affirmed that this property will be found one of the most productive in the kingdom for lead ores.

The mines have been under development by a private company of adventurers, for satisfactorily proving their value previous to their introduction to the mining world; having in view to work them upon a scale commensurate with their reported but now ascertained importance, they have expended £2500 in the purchase of the lease, valued at £7500, also a large amount in clearing levels, erection of drawing engine and other machinery, and made valuable discoveries of lead, which justify the most sanguine expectations of the mines proving to be rich in lead ores.

The operations during the past two months, upon a limited scale, have resulted in the most beneficial results. Ten men have raised sufficient lead to pay 50 per cent. profit, which multiplied, the yield of lead ore is estimated to justify continuous dividends of at least 25 per cent.

The great impetus which the proposed capital will give will fully develope the resources of the property, that gradually increased dividends may be relied on as the works proceed; and each level drained will add to the immediate returns of lead ore.

The capital has been fixed at £40,000, in shares of £5 each, a sum most ample to effectually prove the mine, 5*s*. of which is to be paid at the time of application, and the remainder as found necessary, but any person may pay up in advance, and be allowed 6 per cent. discount thereon.

Full power will be given to the directors to increase the present staff of miners, as found necessary, although the capital be not fully subscribed for, so that no time shall be lost in bringing this valuable mine into a profitable position.

The present proprietors, being impressed with the value of the mine, have consented to take the whole of their interest, £7500, in paid-up shares, leaving £32,500 available, if required, for contingent expenses attending the formation of the company and working capital, which sum is considered as a safe investment, and will repay an amount of interest far exceeding all known securities.

The important geological features of the strata have attracted the attention and excited the admiration of experienced mineralogists, including Sir Roderick Murchison, who has pronounced the Bog Mine to be one of the richest in the kingdom. Its reputation throughout this great lead district bears out the opinion that immediate returns for the capital expended will accrue upon further development.

The buildings on the mine consist of count-house, carpenters' and smiths' shop, dwelling house, whims, engine, dressing-floors, and a commodious chapel and school-rooms.

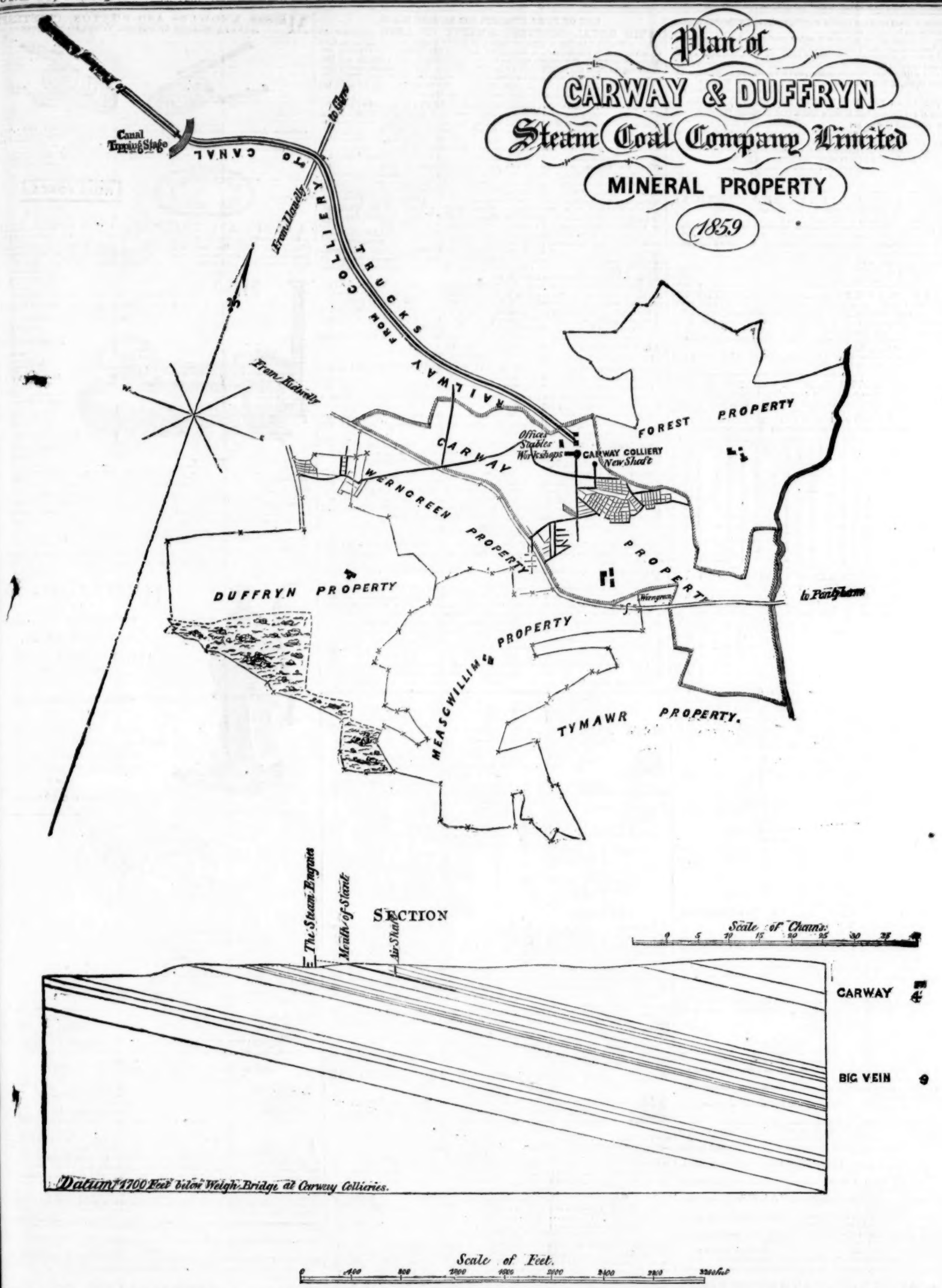
The company being registered under the Joint Stock Act of 1856-1857, with limited liability, no shareholder can be liable for more than the amount of shares held.

REPORT.

June 4, 1859.—Agreeably to your request, I beg to hand you my report of this mine. The pitch in the back of the 40, south of Bunting's shaft, on the north lode, is looking well for a good course of ore; and the end south is now yielding above 2½ tons of lead, worth £40 per fathom. In the back of this level we have two stopes, yielding above 15 cwts. of lead, worth £12 per fathom. The 40, driving west of Office shaft, upon a caunter lode, is looking well for a large bunch of ore. The men have cut into a leader of lead, worth full £15 per fathom. We are progressing satisfactorily in clearing up different places through the mine, and shall continue opening up and clearing the north lode, when I fully expect to set several good pitches on tribute; indeed, it is my belief there is a great quantity of ore ground standing which will pay handsome profits from this place alone, independent of other places above the 50 fm. level, which will yield hundreds of tons of lead ore. To prove this valuable mine commensurate with its importance, I would advise an 80-in. cylinder engine to be erected in the engine-house over the old engine-shaft, which is in good condition, and can soon be made perfect. This shaft should be cleared up from the boat level, 50 fathoms deep, down to the 160 fathom level, which can be done for £5 per fathom, the contractor being supplied with materials, &c. This would be a saving of time and money, and I believe, from the information obtained from former workers, this shaft is the right place to command the mine to the 160 fm. level; below which I would advise it to be continued perpendicular, and not upon the underlie of the lode. The machinery will work much easier, and prevent breakages. The ground in each level is most congenial for lead, and can be driven at a low price to intersect the lodes in each level as the sinking continues. At Bunting's shaft I would recommend a 60-in. cylinder to be erected, which will enable us to clear up the mine quickly, and make handsome returns of lead as we go down. It is my decided opinion, supported also by all the old experienced miners that have worked in the mine, that thousands of tons of lead ores will be raised long before we reach the bottom. Upon the above advice being carried out, it is the universal opinion that the Bog Mine will prove, not only equal to its rich neighbour Snailbeach, but the richest lead mine in the kingdom, and pay to the fortunate shareholders very large and continuous dividends upon the development of the mine, for the capital expended.

Thomas Fuller, Esq. —— SAMUEL MORRIS REDGE.

Application for prospectuses, forms and plans, may be made to MESSRS. GLEDHILL and Co., Leeds; also, THOMAS LEWIS, Esq., Carr's-lane, Birmingham; THOMAS GOSS, Esq., Bath; the Lion Hotel, Shrewsbury; and at the office of the company, 51, Threadneedle-street, London, where every information may be obtained.



THE CARWAY AND DUFFRYN STEAM COAL COMPANY (LIMITED).

Incorporated January, 1858.

...tal £30,000, in 10,000 shares of £5 each, with power in the shareholders in general meeting to increase the capital by the issue of new shares.

DIRECTORS.

...Hon. ... YELVERTON, J.P., Whitland Abbey, Carmarthenshire, Chairman.
...E. PAN..., Esq., 18, Stamford Villas, Fulham.
HENRY WARD, Esq., H.E.I.C.S., K.L., Albany, Piccadilly.
WILLIAM SHAW, Esq., 3, Streatham-street, Bloomsbury.

BROKERS—Messrs. Webb and Gesch, 8, Finch-lane, City, and Stock Exchange.

BANKERS—The London and Westminster Bank (Temple Bar Branch).

OFFICES OF THE COMPANY,—5, GREAT QUEEN-STREET, WESTMINSTER

This company was incorporated and commenced working in January, 1858, the well-known collieries of Carway and Duffryn, and the adjacent mineral properties, known as Forest Fawr, Waungreen, and Maesgwillim coal fields, the produce of which is well known and highly appreciated, not only in those districts, but in the London market, and in most of the ports of England and Ireland.

The collieries are situate in the Gwaindreth Valley, in the parishes of Pembrey and Kidwelly, in the county of Carmarthen, about five miles by canal from the shipping ports of Burry Port and Kidwelly (at which the company have depôts for storing and shipping their coal), about five miles from the Pembrey station of the South Wales Railway. The Carway and Duffryn Collieries have been opened some years, and during the past year this company have expended a considerable sum in further developing these valuable properties, and extending the works.

The collieries on the 1st June inst. were inspected by Mr. W. Harrys, of Llanelly, and his estimate of the collieries, on the present working, is that they are now worth £30,000. Mr. Harrys is well known in the South Wales coal district, and fully competent to form an opinion, as he is at present raising upwards of 400,000 tons of coal annually. The report of Mr. Harrys accompanies this prospectus.

The several properties consist of about 500 acres, and are held under leases at certain rates. These properties are estimated to contain workable coal as follows:—

Carway and Duffryn	9,519,312 tons.
Waungreen	2,120,348 „
Maesgwillim	5,153,734 „
Forest Fawr	2,697,770 „
Total	19,491,164 tons.

There are in all 17 veins, and the chief of them are shown on the Geological Ordnance Survey of Great Britain.

The veins vary from 1 to 9 feet in thickness, but the big vein of 9 feet is the only one being worked at present, which alone is calculated will yield of workable coal 3,473,910 tons, or sufficient to last nearly 60 years at 60,000 tons per annum.

The calculations are carefully made by an experienced mineral engineer, from actual survey, and his report can be seen on application at the company's offices.

The plant at present consists of two steam-engines, with all the winding gear and pumping apparatus in full operation, the newly-erected engine-house and workshops, smithies, storehouses, stabling, offices, &c., the whole constructed in the best possible manner; also, railway plant, trucks and tramways, barges, horses, &c.; in fact, every adjunct necessary at the present moment for raising and shipping with dispatch 200 tons of coal per day.

The annexed plan on a small scale shows the boundaries of the property, and a true section of the coal measures.

Since the 1st of January in the last year, when the company first took possession of these mines, a large sum of money has been expended in improving the underground and surface workings, and whilst these new works have been in progress only a comparatively small quantity of coal has been raised, about 25,000 tons, the whole of which has been readily sold at a good profit. The average raisings at present are at the rate of 60,000 tons per annum. The whole of the improvements are now nearly finished, and when completed 75,000 tons per annum will be the average raisings.

The coal finds a ready sale, and a great portion of it—viz., the stone, or malting coal—is used in making malt for the principal London breweries. The demand at present is greater than the supply, and contracts at highly remunerative prices are being made for large quantities for the current year.

The coal for steam purposes finds a ready sale, with an increasing demand, and contracts are in existence for supplying large quantities for shipment.

The small, or culm, finds also a ready sale, and the supply is scarcely equal to the demand.

The present average selling price of all description of coal (free on board ship) in Pembrey Harbour or Kidwelly Quay is ..... 8s. 0d. per ton.
Cost of production, including royalties and charges of every description, is 5s. 6d. „

The colliery at present is only raising at the rate of 60,000 tons per annum, but no difficulty exists, with the aid of more machinery and plant, to increase the same to 100,000 tons per annum, and with a reduction in the cost of production.

The sale of 60,000 tons at 8s. per ton will give	£24,000 per annum.
The cost of producing 60,000 tons at 5s. 6d. per ton is	16,500 „
Showing an annual profit of	£7,500

Or equal to a dividend of 15 per cent. on the whole capital of the company.

The directors, therefore (believing that they are justified by the present condition of the company, and to enable them further to develope the colliery), propose to raise the further sum of £16,000 by way of preference shares, and that these preference shares shall bear a guaranteed rate at 8 per cent. interest, not redeemable until the expiration of five years.

The gross profit on the working of 60,000 tons being ..... £7500 per annum,
Will be a sufficient security for the 8 per cent. preference shares on £16,000 now proposed to be raised, which interest will amount only to 1280 „
Leaving to be divided among the original shareholders the sum of .. £6220 per annum

The subscribers for these preference shares will have the option at any time in three years from this date to declare their intention of accepting ordinary for preference shares.

Applications for shares in the annexed form may be sent either to the brokers or to the offices of the company.

Llanelly, June 1.—I beg to hand you my valuation of the Carway and Duffryn Collieries, which are situated in the Gwaindreth Valley, near this town.

The property appears to be held upon the usual leases of the district, and consists of the Carway and Duffryn estates, the Forest, Maesgwillim and Waungreen farms, together about 432 acres, with a colliery opened upon the big vein.

This colliery, now at work, is complete with all necessary machinery, plant and appliances, stalls and openings, all at the present moment fully equal to the production of 200 tons per day of first-class coal.

I have gone carefully over this colliery, and estimate its value at 30,000*l*. I may men-

tion that this estimate is based upon the present workings only, and without taking into account the probable future increased working.

I am at this moment concerned for collieries together producing daily from 1000 to 1200 tons; I must, however, say that I never before in the course of my experience examined a finer district of coal, or one presenting better prospects, than the Carway and Duffryn Collieries, and to make the value of the property considerably more than I have given; it requires only a little time for development, and the providing of the necessary plant, for the removal of larger daily quantities.

WILLIAM HARRYS.

Mineral Survey, Llanelly.

FORM OF APPLICATION FOR £3 PER CENT. PREFERENCE SHARES.

To the Directors of the Carway and Duffryn Steam Coal Company (Limited).

GENTLEMEN,—I request you to allot me preference bonds of £5 each of the above company, not redeemable until five years from the date thereof, with interest at £3 per cent. half-yearly in the meantime, which I undertake to accept, and have paid the deposit of £2 10s. into your bankers, as certified by the accompanying receipt, and agree to pay the balance of £2 10s. within 30 days after notice from you to that effect.

Name .....

Address .....

Dated this day of , 1859. 136

KENNINGTON AGRICULTURAL AND CHEMICAL COLLEGE, LOWER KENNINGTON LANE, NEAR LONDON.

PRINCIPAL—J. C. NESBIT, F.G.S., F.C.S.

Youths intending to become Farmers, Land Stewards, Chemical and Manure Manufacturers, or Managers of Mining Property, will find the course of instruction in the College such as to fully qualify them for their respective pursuits. The terms for senior and junior students may be known on application to the Principal.

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ANALYSES and ASSAYS of EVERY DESCRIPTION are PROMPTLY and ACCURATELY EXECUTED in the Laboratories of the College. 137

ARTIFICIAL MANURES, &c.—MANUFACTURERS and OTHERS ENGAGED in MAKING ARTIFICIAL MANURES MAY OBTAIN every NECESSARY INSTRUCTION for their ECONOMICAL and EFFICIENT PREPARATION by applying to J. C. NESBIT, F.G.S., &c., Principal of the Agricultural and Chemical College, Kennington, London. Analyses of Soils, Guanos, Superphosphates of Lime, Coprolites, &c., and Assays of Gold, Silver, and other Minerals, are executed with accuracy and dispatch.

Gentlemen desirous of receiving instructions in Chemical Analysis and Assaying will find ample facility and accommodation at the College. 138

MAPPIN'S ELECTRO-SILVER PLATE & TABLE CUTLERY.—MAPPIN BROTHERS (Manufacturers by Special Appointment to the Queen) are the only Sheffield makers who supply the consumer in London. Their London Show Rooms, 67 and 68, KING WILLIAM STREET, LONDON BRIDGE, contain by far the LARGEST STOCK OF ELECTRO-SILVER PLATE and TABLE CUTLERY in the world, which is transmitted direct from their manufactory, QUEEN'S CUTLERY WORKS, SHEFFIELD.

	Fiddle Pat.	Double Thread.	King's Pat.	Lily Pat.
12 Table Forks, best quality	£ 1 16 0	£ 2 14 0	£ 3 0 0	£ 3 12 0
12 Table Spoons, best quality	1 16 0	2 14 0	3 0 0	3 12 0
12 Dessert Forks, best quality	1 7 0	2 0 0	2 4 0	2 14 0
12 Dessert Spoons, best quality	1 7 0	2 0 0	2 4 0	2 14 0
12 Tea Spoons, best quality	0 16 0	1 4 0	1 7 0	1 16 0
2 Sauce Ladles, best quality	0 8 0	0 10 0	0 11 0	0 13 0
1 Gravy Spoon, best quality	0 7 0	0 10 6	0 11 0	0 13 0
4 Salt Spoons (gilt bowls), best qu.	0 6 8	0 10 0	0 12 0	0 14 0
1 Mustard Spoon, best quality	0 1 8	0 2 6	0 3 0	0 3 6
1 Pair Sugar Tongs, best quality.	0 3 6	0 5 6	0 6 0	0 7 0
1 Pair Fish Carvers, best quality.	1 0 0	1 10 0	1 14 0	1 18 0
1 Butter Knife, best quality	0 3 0	0 5 0	0 6 0	0 7 0
1 Soup Ladle, best quality	0 12 0	0 16 0	0 17 6	1 0 0
6 Egg Spoons (gilt), best quality.	0 10 0	0 15 0	0 18 0	1 1 0
Complete Service	£10 13 10	£15 16 6	£17 18 6	£21 4 6

Any article can be had separately at the same prices.

One Set of Four Corner Dishes (forming eight dishes), £8 8s.; One Set of Four Dish Covers (one 20 in., one 18 in., and two 14 in.), £10 10s.; Cruet Frame (four glass), 24s.; Full Size Tea and Coffee Service, £9 10s. A Costly Book of Engravings, with prices attached, sent per post on receipt of 12 stamps.

	Ord. qual.	Medium qual.	Best qual.
Two dozen Full Size Table Knives, Ivory Handles	£2 4 0	£3 6 0	£4 12 0
1½ dozen Full Size Cheese ditto	1 4 0	1 14 6	2 11 0
One Pair Regular Meat Carvers	0 7 6	0 11 0	0 15 6
One Pair Extra Sized ditto	0 8 6	0 12 0	0 16 6
One Pair Poultry Carvers	0 7 6	0 11 0	0 15 6
One Steel for Sharpening	0 3 0	0 4 0	0 6 0
Complete Service	£4 16 0	£6 18 6	£9 16 6

MESSRS. MAPPIN'S table knives still maintain their unrivalled superiority; all their blades, being their own Sheffield manufacture, are of the very first quality, with secure ivory handles, which do not come loose in hot water, and the difference in price is occasioned solely by the superior quality and thickness of the ivory handles. 139

MAPPIN BROTHERS, 67 and 68, King William-street, City, London; Manufactory, Queen's Cutlery Works, Sheffield.

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ELEMENTARY TREATISE ON IRON METALLURGY, UP TO THE MANUFACTURE OF PUDDLED BARS:

Built upon the Atomic System of Philosophy, the Elements operated upon being Estimated according to Dr. Wollaston's Hydrogen Scale of Equivalents.

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"I do not hesitate to say Mr. Rogers's work is the most complete combination of sound science and sound practice that has yet appeared on Iron—beyond comparison."—DAVID MUSHET.

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MINING AND COLLIERY OPERATIONS IN THE UNITED STATES.

THE UNITED STATES RAILROAD AND MINING REGISTER. Edited and published by Thomas S. Fernon, at No. 423, Walnut-street, Philadelphia. To subscribers in Great Britain, 13s. 6d. ($3), payable in advance. Established May, 1856, issued weekly. Has a circulation throughout the United States, Canada, and Great Britain.

The Register, as its name imports, is devoted to the discussion and dissemination of occurrences and results bearing upon the practical theme of transportation by car upon the iron rail. And as for cars, artificial trackways must be constructed; Railroads, at the same time that they supply the most expeditious communication, exact the largest outlay of money, and, being of perishable materials, demand constant repair and watchfulness. Hence all improvements in the permanent way of railroads, and, also, in the rolling stock and machinery of railroads, tending to cheapen and facilitate transportation, the *Register* is ever ready and anxious to give early and appreciative notice.

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Prices Current of Stocks, Coal, and Metals, in the principal American and British markets, are given weekly, from the best authorities.

Correspondence on subjects treated of in the *Register* will be gladly received and given space. 142

LIST OF PRIZE SUBJECTS FOR SESSION 1859-60.

THE ROYAL SCOTTISH SOCIETY OF ARTS proposes to AWARD PRIZES of different values, of Thirty Sovereigns and under, in Gold or Silver Medals, Silver Plate, or Money, for APPROVED COMMUNICATIONS, primarily submitted to the Society, relative to INVENTIONS, DISCOVERIES, and IMPROVEMENTS in the MECHANICAL and CHEMICAL ARTS in general, and in their relations to the FINE ARTS, and also to means by which the NATURAL PRODUCTIONS of the country may be made more available. The Society suggests the following as a few of the many subjects that may be attended to, viz.:—

I.—INVENTIONS, DISCOVERIES, or IMPROVEMENTS in the USEFUL ARTS.

1. MECHANICAL ARTS.—Inventions or Improvements in applying the Motive Power of Men and Animals—in Wind and Water Prime Movers—in Steam and other heat Engines, and their various applications—in Pumping, Blowing, Rolling, Sawing, Agricultural, and other Engines and Machines—in Cotton and other textile Manufacturing Mills—in Shipbuilding, Wood, Iron, and Steel—in Lighthouses—in Marine Propellers—in Railways, Plant and Signals—in Electro-Magnetic Motive Power—in Electric and other Telegraphic Apparatus, Submarine and Aërial—in Photographic Apparatus—in Fire-Proof Buildings—in Water Supply—in Paving—Sewerage—in Economical Appliances for Increasing the Sanitary Condition of Towns—in Smoke Consumption and Extinguishing Fires—in Gas Works—in Canals and Inland Navigation—in Tools, Implements, and Apparatus for the various Trades—in Bricks, Encaustic Tiles, Cements and Mortars—in Printing Machines, Cases, and Rollers—in Stereotyping—in Cranes—in the Machinery for Collieries—in Preserving Timber and Metals in Marine Works—in Optical Apparatus for Astronomy, Surveying, and Levelling—in Manufacture of Paper, &c.

2. CHEMICAL ARTS.—Inventions or Improvements in New and Useful Applications of Gutta Percha and Vulcanised India-rubber, or similar Gums—in the Economical Extraction of Chemical Principles or Useful Substances, as Paraffine, &c., from Coal, Porcelain, Clay from Granite or Felspar, and Metals generally from their Ores and Oxides—in Dyes—in Paints—in Paper—in Glass, especially for Lenses—in methods of rendering the Electric Light available in Practice, &c.

3. RELATIVE TO THE FINE ARTS.—Inventions or Improvements in Photographic Processes, in "Carbon" Printing, and in Methods of Printing Photographs from their Impressions on Steel or Copper-plates, or Lithographic Stones—in Electrotype Processes—in Die Sinking—in Methods of Illustrating Books to be Printed with the Letter-press—in Paper Hangings—in Articles of Porcelain, Common Clay, or Metal—in Glass Staining in Engraving on Stone—in Chromo-Lithography—in "Nature" Printing.

4. NATURAL PRODUCTIONS.—Discovery of Plumbago Mines—of Slate Pencil of good quality—Whetstones—of Woods suitable for Engraving.

II. - EXPERIMENTS applicable to the USEFUL ARTS.

III.—COMMUNICATIONS of PROCESSES in the USEFUL ARTS practised in this or other countries, but not generally known.

IV.—PRACTICAL DETAILS of PUBLIC or OTHER UNDERTAKINGS of NATIONAL IMPORTANCE already executed, but not previously published; or valuable Suggestions for originating such undertakings.

KEITH PRIZE (value Thirty Sovereigns).—For some important "Invention, Improvement, or Discovery, in the Useful Arts, which shall be primarily submitted to the Society" during the Session.

MACDOUGALL BRISBANE BIENNIAL PRIZE (value Ten Pounds).—"To the Authors or Inventors of Communications of Merit, which shall be approved of by the Society, or its committee, and judged by them deserving of such distinction."

REID AND AULD PRIZES.—For the First, Second, and Third best Models of "Anything New in the Art of Clock or Watch Making, by Journeymen or Master Watch and Clock Makers." If these should be considered worthy of prizes, the year's interest of the Reid and Auld Bequest, being about Seven Guineas, divided among them in such proportions as the Prize Committee shall fix, according to merit. To such as deserve it, the society may add to the amount of the prize out of its general funds.

GENERAL OBSERVATIONS.

Communications lodged in competion for prizes shall not have been patented, nor previously published, nor read before any other society, but patented articles may be exhibited and described.

The descriptions of the various inventions, &c., must be full and distinct, and be written on foolscap paper, with binding margins.

The relative drawings to be on imperial drawing paper, and in bold lines, or strongly coloured, so as to be easily seen at about the distance of 30 feet when hung up in the hall.

The Society shall be at liberty to publish in their Transactions the papers submitted to them, or abstracts thereof. Models, &c., for which prizes are given, to be held the property of the Society, the value of the models, &c., being separately allowed for.

Communications to be sent free to the secretary, Chambers, 5, Hill-street, Edinburgh, on or before 1st of November, 1859, in order to ensure their being read and reported on during the session, the ordinary meetings of which commence in November, 1859, and end in April, 1860, but those which cannot be lodged earlier will be received up to the 1st April, 1860, although they may possibly not be read or reported on till the following session.

By order, JOHN BEATSON BELL, Sec.

Edinburgh, June, 1859. 143

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